calculation are shifted to the minus side by about 10 % from those in actual heads. Considering the fact that the usable bias point range falls plus/minus 10 % of the best bias point value, it can be said that the good bias point range will fall between 30 % and 50 % to be obtained in calculation. Accordingly, when the bias point falls between 30 % and 50 %, as obtained according to the calculation shown above, it could be judged that the bias point values within the range are good for practical use.

The problems with some conventional spin valve films are described in detail hereunder, with reference to the bias point calculation formulae mentioned above.

Comparative Case 1: ordinary spin valve (with neither high-conductivity film nor Synthetic AF)

5 nanometer Ta/2 nm NiFe/0.5 nm Co/2 nm Cu/2 nm CoFe/7 nm IrMn/5 nanometer Ta (1)

The formula (1) indicates the laminate structure of the spin valve, in which are shown the elements constituting the layers and their thicknesses (nanometers). The film of this Comparative Case is a modification of a prior art spin valve film in which only the free film is thinned. The bias points in this film constitution are calculated.

Of the bias point formulae (1-1) to (1-5) noted above, the current magnetic field of the formula (1-5) is the most difficult to obtain. This is because the current flow ratio,

C, of the formula (1-5-1) is difficult to obtain. In the thinned film, the specific resistance of each layer is influenced by the crystallinity and the current distribution, and significantly differs from the specific resistance of the bulk. For practicable calculation as much as possible, we, the present inventors took the following measure and succeeded in obtaining the accurate current flow ratio, C.

For obtaining the specific resistance of each layer, a spin valve film sample having the constitution noted above is prepared. For obtaining the specific resistance of a predetermined layer, a few samples in which the thickness of the layer is varied by plus/minus 2 nanometers are prepared. In those samples, the relationship between the thickness of the layer and the conductance is obtained through linear extrapolation. The reason for the process is because actual data could not be obtained according to the well-known technique of obtaining the specific resistance of thin, single-layer films. In order to minimize the influences of crystallinity and those of current distribution, we, the present inventors have found through our experiments that the best way for accurate determination is to prepare film samples in which even the overlying and underlying layers are of practicable materials and to determine the conductance difference within the small thickness range as mentioned above.

The specific resistance of each layer as obtained

according to the method is influenced little by the crystallinity and, in addition, could cancel the influences of current distribution thereon. Therefore, the data of the current flow ratio, C, of the formula (1-5-1) obtained according to this method are much more accurate than those obtained in a simple conductor in which is used the specific resistance of single-layer films. According to the method, it has become possible to calculate and estimate the current magnetic field with high accuracy, which, however, is difficult in the prior art technique.

The data of the specific resistance of each layer as obtained according to the method mentioned above are as follows: NiFe has 20 μΩcm; CoFe 13 μΩcm; spacer Cu 8 μΩcm; IrMn 250 μΩcm. If the underlayer of Ta (tantalum) is thick, its specific resistance will greatly vary through crystallization. The cap Ta is much influenced by the surface oxides. Therefore, their accurate data could not be obtained. The specific resistance of the Ta layer is presumed to be 100 μΩcm. Based on those data, the current flow ratio of each layer is obtained, and the current magnetic field Hcu is calculated according to the formula (1-5).

The value of Hin is 25 Oe, as measured. Hpin is obtained according to the formula (1-4).

In the film constitution of this case, the height is shortened while the thickness of the pinned layer is thick.